## REMARKS

This paper is in response to the Final Office Action of August 17, 2007. Applicants have amended the application as set forth above. Specifically, Claim 1 has been amended. Claim 9 has been canceled. Upon the entry of the amendments, Claims 1-3, 5-7, and 21-24 are pending in this application. No new matter is added by the amendments as discussed below. Applicants respectfully request the entry of the amendments and reconsideration of the application in view of the above amendments and the following remarks.

Discussion of Amendment

The amendments to Claim 1 are made to delete "rhenium (Re)" from Claim 1. In addition, Claim 9, which recited a rhenium alloy, has been canceled. Thus, no new matter has been added by the amendments.

As such, Applicants respectfully submit that the amendments are fully supported by the application as originally filed and do not constitute the addition of a new matter. Therefore, Applicants respectfully request the entry of the amendments.

Rejection Under 35 U.S.C. § 103

The Examiner rejected Claims 1, 6, and 7 under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. (U.S. Patent No. 6,482,740) in combination with Nakano et al. (U.S. Patent Application Publication No. 2001/0030366). Claims 2, 3, 5, 9, and 21-24 were rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Nakano et al./Soininen et al. and further in view of Kim et al. (U.S. Patent No. 6,936,535), Koh et al. (U.S. Patent No. 6,720,262), and Gelatos et al. (U.S. Patent No. 5,391,517).

Standard for Obviousness Rejection

The Patent and Trademark Office has the burden under section 103 to establish a *prima facie* case of obviousness. *In re Piasecki*, 745 F.2d 1468, 1471-72, 223 USPQ 785, 787-87 (Fed. Cir. 1984). To establish a *prima facie* case of obviousness, the following criteria must be met: there must be a reasonable expectation of success; and the prior art reference (or references when combined) must teach or suggest all the claim limitations. *See* M.P.E.P. § 2143.

Claims 1, 6, and 7

With respect to Claim 1 as amended, Applicants submit that the Office Action fails to establish a *prima facie* case of obviousness. Soininen et al. and Nakano et al., individually or in combination, fail to teach or suggest all the limitations of Claim 1 as amended.

Claim 1 requires: 1) providing an insulation layer having a damascene trench therein on a substrate, the damascene trench including sidewalls; 2) forming ***a barrier layer containing ruthenium or its alloy directly on surfaces of the insulation layer*** *including the sidewalls within the damascene trench* using an atomic layer deposition (ALD) method; and 3) forming a copper layer *directly on said barrier layer using chemical vapor deposition such that the barrier layer intervenes between the copper layer and the sidewalls of the damascene trench within the insulation layer.*

Thus, a single Ru barrier layer to copper diffusion is formed to intervene between the insulation layer and the sidewalls of the damascene trench within the insulation layer. Recitation of direct formation also requires the copper to ***directly*** overlie the barrier while the barrier ***directly*** overlies the insulating trench sidewalls.

The prior art references do not teach or suggest forming such a single Ru barrier layer which intervenes between, and directly contacts, the copper layer and the sidewalls of the damascene trench within the insulation layer. Soininen et al. teaches forming ***two*** layers (a metal nitride barrier layer and a Ru- or Re-containing seed layer) between an insulation layer and copper in a damascene trench, and thus fails to teach or suggest forming a Ru-containing barrier ***directly on surfaces of the insulating layer.*** Nakano et al. fails to teach or suggest ***a barrier film containing Ru.***

a. Disclosure of Soininen et al.

Soininen et al. discloses a dual damascene structure. Soininen et al., Figure 1 below. The dual damascene structure consists of a metallization layer 2, e.g., Cu, an insulating layer 4, e.g., $SiO_2$, a via etch stop 6 made of, e.g., $Si_3N_4$, a via level insulator 8, e.g., $SiO_2$, a trench etch stop 10 made of, e.g., $Si_3N_4$, a trench level insulator 12, e.g., $SiO_2$, a diffusion barrier 14, e.g., TaN, a seed layer 16 (e.g., metal oxides such as $ReO_2$ and $RuO_2$) and a via/trench fill metal 18, e.g., Cu.

*See id.* at Figure 1; column 5, lines 46-52; column 6, lines 43-53; and column 7, lines 21-37.

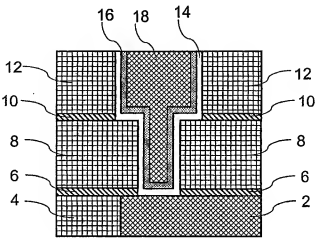



Fig. 1

Soininen et al. also discloses forming a Ru or Re layer by an ALD type process. *Id.* at column 5, lines 5-25. In addition, Soininen et al. discloses depositing copper on a diffusion barrier layer using a CVD process. *Id.* at column 3, lines 15-35. As indicated in the Office Action, Soininen et al. does not disclose forming a Ru or Re layer ***directly*** on an insulating layer.

b. Disclosure of Nakano et al.

Nakano et al. discloses semiconductor devices having a wiring structure made of copper. Nakano et al., paragraph 0002. Among other things, Nakano et al. discloses (a) a step of forming an insulating film 4 on a substrate 10a; (b) a step of forming a wiring groove 7 and connection hole 10 in the insulation film 4; (c) a step of forming a barrier film 3 in the wiring groove 7; (d) a step of forming a seed layer 5 on the barrier film 3; and (e) a step of embedding copper film 6 in the wiring groove 7 and hole 10. *Id.* at paragraphs 0029-0033; Figures 1(a)-1(h) below. The barrier film 3 can be formed of a high melting point material such titanium, tantalum and tungsten, alloy thereof, or the nitrides thereof. *Id.* at paragraph 0038. The barrier film 3 can also be formed of a cobalt alloy containing (1) cobalt, (2) at least one of chromium, molybdenum, tungsten, rhenium, thallium, and phosphorus, and (3) boron. *Id.* at paragraphs 0017 and 0025. Nakano et al., however, does not disclose use of ruthenium as a barrier film material.

FIG. 1(a)

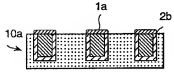



FIG. 1(b)

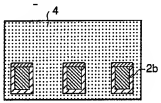



FIG. 1(c)

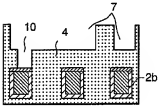



FIG. 1(d)

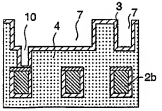



FIG. 1(e)

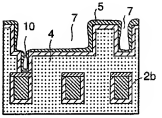



FIG. 1(f)

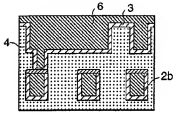



FIG. 1(g)

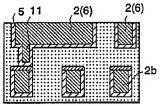
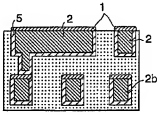



FIG. 1(h)




c. Claim 1, 6, and 7 v. Soininen et al./Nakano et al.

Soininen et al. does not disclose "forming a barrier layer containing ruthenium (Ru) or its alloy ***directly*** on surfaces of an insulation layer," as recited in Claim 1 as amended. Soininen et al. fails to disclose a single barrier layer which intervenes directly between both an insulation layer and a copper layer. Instead, Soininen et al. discloses forming a metal nitride barrier layer 14 between a Ru or Re-containing seed layer 16 and an insulation layer 8, 12. *See* Soininen et al., Figure 1; and column 5, lines 46-52. The trench fill metal (e.g., copper) 18 is not formed

directly on this barrier layer 14. Soininen et al. also discloses forming a seed layer (formed of, for example, ruthenium or rhenium oxide) 16 between the trench fill metal 18 and the barrier layer 14. This seed layer 16 is not formed directly on surfaces of the insulation layer 8, 12. *See id.* Therefore, Soininen et al. does not disclose the limitation of Claim 1.

Nakano et al. does not cure this deficiency. Nakano et al. ***does not disclose a barrier layer containing ruthenium or its alloy***, as recited in Claim 1 as amended. Nakano et al. only discloses a barrier film 3 formed of titanium, tantalum and tungsten, alloy thereof, or the nitrides thereof; or a cobalt alloy containing (1) cobalt, (2) at least one of chromium, molybdenum, tungsten, rhenium, thallium, and phosphorus, and (3) boron. Nakano et al., paragraphs 0017, 0025, and 0038. Therefore, Nakano et al. does not disclose the limitation of Claim 1.

Put another way, neither of the references recognizes ruthenium (Ru) as a suitable sole barrier ***between and directly contacting*** both copper and the insulator in which a damascene trench is formed. Soininen et al. uses both a metal nitride layer and a Ru-containing layer in that barrier/seed position. Nakano et al. does not disclose a Ru-containing barrier in that position.

As set forth above, Soininen et al. and Nakano et al., either individually or in combination, fail to teach or suggest all the limitations of Claim 1. Thus, the Office Action fails to establish a *prima facie* case of obviousness. Therefore, Claim 1 is allowable under 35 U.S.C. 103(a) over Soininen et al. in combination with Nakano et al. Claims 6 and 7 depend directly or indirectly from Claim 1, and are allowable for substantially the same reasons as explained above.

Claims 2, 3, 5, 9, and 21-24

With respect to Claims 2, 3, 5, and 21-24, Applicants submit that the Office Action fails to establish a *prima facie* case of obviousness. Claim 9 has been canceled, rendering the rejection to this claim moot. Soininen et al., Nakano et al., Kim et al., Koh et al., and Gelatos et al., either alone or in combination, do not teach or suggest all the limitations of the claims.

Claims 2, 3, 5, and 21-24 depend directly or indirectly from Claim 1. As set forth above, Soininen et al. and Nakano et al., either individually or in combination, fail to teach or suggest all the limitations of Claim 1. Kim et al., Koh et al., and Gelatos et al., either individually or in combination, fail to cure this deficiency. None of these three references teaches or suggests "forming a barrier layer containing ***ruthenium (Ru) or its alloy*** directly on surfaces of an

insulation layer," as recited in Claim 1 as amended. Therefore, Claims 2, 3, 5, and 21-24 are allowable under 35 U.S.C. 103(a) over the combination of Soininen et al./Nakano et al. and further in view of Kim et al., Koh et al., and Gelatos et al.

For all of these reasons, Applicants respectfully request withdrawal of this rejection, and allowance of the pending claims.

## CONCLUSION

In view of Applicants' amendments to the claims and the foregoing remarks, Applicants respectfully submit that the present application is in condition for allowance. Should the Examiner have any remaining concerns, which might prevent the prompt allowance of the application, the Examiner is respectfully invited to contact the undersigned at the telephone number appearing below.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

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Dated: October 15, 2007

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